Swan Valley Northern Bog Lemming Survey

Final Report to:

Montana Department of Transportation
2701 Prospect Avenue
PO Box 201001
Helena, MT 59620-1001

Submitted by:

James D. Reichel
and
Stan G. Beckstrom

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Montana Natural Heritage Program
1515 E. 6th Avenue
P.O. Box 201800
Helena, MT 59620-1800

INTRODUCTION

The northern bog lemming (Synaptomys borealis) is a small, grayish brown, vole-like microtine, related to the true arctic lemmings (Lemmus). Nine poorly differentiated subspecies are currently recognized. The northern bog lemming has a total length of 118-140 mm including its very short tail (19-27 mm) (Banfield 1974, Hall 1981). The combination of a tail less than 28 mm and a longitudinal grove in the upper incisors distinguish the northern bog lemming from all other mice found in Montana. It is boreal in distribution, occurring in North America from near timberline in the north, south to Washington, Idaho, Montana, Minnesota, and New England. It typically inhabits sphagnum bogs, but is also occasionally found in mossy forests, wet sub-alpine meadows, and alpine tundra. One subspecies (S.b. artemisiae) lives on sagebrush hillsides in eastern British Columbia (Anderson 1932). Southern bog lemmings (S. cooperi) also inhabit a wide variety of habitats, all of which are marginal for Microtus; bog lemmings may be competitively excluded from better quality habitats by Microtus (Doutt et al. 1973, Linzey 1981). The northern bog lemming is rarely trapped and is one of the least known mice in North America.

A few relict populations occur in the lower 48 states; the subspecies chapmani occurs in Montana, Idaho, and northeast Washington (Hall 1981). Bog lemmings are known from 4 locations in Idaho and 8 in Washington, all from within 80 km of the Canadian border (Johnson and Cheney 1953, Wilson et al. 1980, Reichel 1984, Groves and Yensen 1989, D. Johnson pers. comm.). The reasons for the disjunct nature of the populations may include: 1) the localized nature of its primary habitat; and 2) the currently patchy distribution of a boreal species that was more widely distributed during the Pleistocene (a glacial relict).

Prior to 1992, evidence of bog lemmings in Montana included: 1) 2-3 locations on the west side of Glacier National Park (Wright 1950, Weckwerth and Hawley 1962, Hoffmann et al. 1969); 2) Shoofly Meadows in the Rattlesnake drainage north of Missoula (Adelman 1979), and 3) a single skull recovered from a Boreal Owl (Aegolius funereus) pellet west of Wisdom (J. Jones pers. comm.); where the owl captured the lemming was unknown. In 1992 we trapped 21 riparian areas finding five new populations of northern bog lemmings (Reichel and Beckstrom 1993). These included: 1) Sunday Creek drainage, Lincoln Co.; 2) a fen along Bowen Creek, Lincoln Co.; 3) around a pond in upper South Fork Hawkins Creek, Lincoln Co.; 4) meadows along Meadow Creek, Ravalli Co.; and 5) Maybee Meadows, Beaverhead Co. The Maybee Meadows site was the southern-most known population of the species outside of New England and the only Montana population from east of the Continental Divide.

The U.S. Forest Service, Region 1, lists the northern bog lemming as Sensitive. The species is listed as a Species of Special Concern

by the Montana (Genter 1992) and Idaho Natural Heritage Programs (Moseley and Groves 1990).

We completed a survey for northern bog lemmings in the Swan Valley during 1993. The goals included:

1) surveying at least 3, and at most 10 sites with potential habitat for bog lemmings along three segments of proposed projects on Montana Highway 83;
2) describing habitat where bog lemmings were found, if any; and
3) preparing a bibliography of literature on northern bog lemmings.

METHODS AND MATERIALS

Potential bog lemming sites were determined during field reconnaissance. It was decided to trap 5 sites along the project areas. One site, North of Salmon Lake, was trapped in the Clearwater Junction - North Project area. This was the best habitat in this Project area, but very unlikely to have bog lemmings. One site, Pierce Bog, was trapped in the Condon - North & South Project area. This site has some suitable bog lemming habitat, but is very small and isolated. Three sites, Mile 49 Pond, South of Simmons Meadows, and Point Pleasant Fen, were trapped in the Missoula County Line - North Project area. All had some potential bog lemming habitat, but they had very small areas with deep sphagnum moss mats. Three additional sites within the general project area but up to several miles off the highway were also trapped to determine general bog lemming distribution in the area (Swan River Fen PRNA, Lost Creek Meadows, and Plum Creek Fen). These sites had excellent habitat with extensive moss mats.

From 27 June - 23 July 1993 we used Museum Special snap-traps to sample 8 sites in the Highway 83 corridor (Table 1). Traps were baited with a combination of peanut butter and rolled oats, either alone or with E.J. Dailey's muskrat lure. Two traps with different baits were placed within 2 m of each other at each station. We placed each trap at a location to maximize success (runway, burrow, etc.). Stations were placed 5-20 m apart.

Trapping effort ranged from 143 to 227 trap nights over 3-4 nights. A trap night is equivalent to one trap set for one 24-hour period (traps sprung and empty, or completely missing, are not counted).

RESULTS

No northern bog lemmings (Synaptomys borealis) were found. Trapping sites are listed in Table 1 and results of the trapping are listed in Table 2. Maps of all trapping sites are in Appendix 1.

Table 1. Sites trapped during 1993 northern bog lemming surveys.

Site	Location	Elev.	Date	Trap Nights
Clearwater Junction-North				
N. of Salmon Lake, Missoula Co.	T16N R15W S25	3920	30 Jun-2 Jul	221
Condon North and South				
Pierce Bog, Missoula Co.	T19N R16W S21	4300	30 Jun-2 Jul	227
Missoula County Line North				
Mile 49 Pond, Missoula Co.	T22N R17W S34	3540	20-22 Jul	215
S. of Simmons Meadows, Lake Co.	T23N R17W S32	3390	28-30 Jun	143
Point Pleasant Fen, Lake Co.	T24N R17W S19	3210	20-22 Jul	216
Adjacent Areas				
Plum Creek Fen, Lake Co.	T23N R18W S1	3330	20-23 Jul	226
Swan River Fen PRNA, Lake Co.	T24N R18W S2	3120	28-30 Jun	202
Lost Creek Meadows, Lake Co.	T25N R18W S36	3180	20-23 Jul	220

Table 2. Results of snap trapping during 1993 northern bog lemming surveys.

Site	Trap	Total number of each species caught[1]													
	Nights	SOPA	SOVA	SOCI	SOMO	SOSP	MIPE	MILO	PHIN	SYBO	CLGA	ZAPR	PEMA	NECI	MUMU
N. of Salmon Lake	221	1	5			1	4	1				5	24		
Pierce Bog	227		5		1	2	12				1		4		
Mile 49 Pond	215	2	8				15					1			
S. of Simmons Meadows	143		8		1	1	2				3				
Point Pleasant Fen	216		7	3	1		16					2			
Plum Creek Fen	226		7	1			6					1			
Swan River Fen PRNA	202		28				7				2				
Lost Creek Meadows	220		1	1			12						1		
Grand Total	**1670**	**3**	**69**	**5**	**3**	**4**	**74**	**1**	**0**	**0**	**6**	**9**	**29**	**0**	**0**

[1]SOPA=Sorex palustris; SOVA=Sorex vagrans; SOCI=Sorex cinereus; SOMO=Sorex monticolus; SOSP=Sorex spp.; MIPE=Microtus pennsylvanicus; MILO=Microtus longicaudus; PHIN=Phenacomys intermedius; SYBO=Synaptomys borealis; CLGA=Clethrionomys gapperi; ZAPR=Zapus princeps; PEMA=Peromyscus maniculatus; NECI=Neotoma cinerea; MUMU=Mus msculus.

DISCUSSION

Bog lemmings are known from across the northwest corner of the state east to the Rocky Mountain Front, and south through the mountains to near Lost Trail Pass on the Continental Divide.

During our trapping in 1992 lemmings were found at 5 of 6 sites that appeared to have good lemming habitat (not at Tom Poole Lake). However, during 1993 sixteen sites we trapped had apparently good lemming habitat and yet we failed to capture them at 11 state-wide (Sunday Creek 2-4, Magnesia Creek, bog NW of Lost Lake, Bent Flat Fen, Trail Creek Fen, Swan River Fen, Lost Creek Fen, Plum Creek Fen, and Sawmill Flat). Either the lemmings are at those sites and we failed to detect them, or we sampled more sites with apparently good habitat, which actually lacked lemmings, in 1993. Probably a combination of the two is actually the case.

If they were present but we failed to detect them, several explanations are possible. First, lemmings populations in Montana in general may have been lower in 1993 than 1992. At sites where lemmings were caught in 1993 we averaged 1.40 lemmings per 100 trap nights; this compares to 1.67 in 1992. Additionally, we trapped more voles in general per trap night in 1993 than 1992; voles which cycle, typically have synchronous highs and lows for all species within a habitat. Second, lemming populations at more individual sites (rather than region wide) may have had low populations simply by chance. Third, given the difficulty in trapping lemmings we may just have been luckier in 1992 than 1993. This may be the likeliest explanation in the Sunday Creek habitat complex.

If the sites actually lacked lemmings several explanations again are possible. First, some relatively large areas do not have lemmings because they were extirpated since the Pleistocene or never recolonized following the melting of the glaciers. Of 11 areas trapped with good habitat but lacking lemmings, 5 were in the Swan River or adjacent South Fork Flathead drainages. This was surprising since there were multiple good habitat patches in relatively close proximity to each other. It may be that northern bog lemmings do not occur, at least at low elevations, in the Swan Valley area. Second, patches within a metapopulation may frequently have extirpations and recolonizations; this may be the case in the Sunday Creek habitat complex. However, if this were common I would not expect there to be as many apparently isolated lemming populations as we have found.

Annotated Bibliography

Adelman, E. B. 1979. A survey of the nongame mammals in the Upper Rattlesnake Creek drainage of western Montana. [M.S. Thesis] University of Montana, Missoula. 129 pp.

Small mammal diversity, niche width and niche overlap were studied in the Upper Rattlesnake Creek drainage, Montana. Snap-trap results, habitat associations and observations are described. For SYNAPTOMYS: habitat was a wet sedge-bluejoint meadow (subalpine fir/bluejoint-bluejoint habitat type); one male caught 9/8/78 in 200 trap-nights; measurements; associated species included: SOREX VAGRANS, CLETHRIONOMYS GAPPERI, and MICROTUS PENNSYLVANICUS.

Allen, J. A. 1903. Mammals collected in Alaska and northern British Columbia by the Andrew J. Stone expedition of 1902. Bull. Amer. Mus. Nat. Hist. 19:521- 567.

For SYNAPTOMYS BOREALIS: Describes the Type specimen of SYNAPTOMYS CHAPMANI, sp. nov. (=S. BOREALIS) by an adult male specimen taken in July 1901 in Glacier, B.C. Gives external and skull measurements and pelage description.

Allen, J. A. 1904. Mammals collected in Alaska by the Andrew J. Stone expedition of 1903. Bull. Amer. Mus. Nat. Hist. 20:273-292.

Gives lists of all locations trapped and species at each (arranged in species accounts). 66 SYNAPTOMYS BOREALIS were taken at 5 locations trapped. 1/3 were adults, 4 females and 15 males. Measurements were taken and separated by sex. At Seldovia SYNAPTOMYS was found “most frequently in little marshy meadows, but was also sometimes taken in timber in places like those inhabited by red- backed mice.”

Anderson, R. M. 1932. Five new mammals from British Columbia. Natl. Mus. Can. Bull. 70:99-119.

Describes 5 new species of mammals from Canada including Type of SYNAPTOMYS BOREALIS ARTEMISIAE from Stevenson Creek, SW of Princeton at 2400 ft elevation. Known only from Similkameen valley from 2400-5600 ft. Description of color, size, skull. Five individuals (4 males, 1 female) were taken at 2400 ft site, 4 (2 males, 2 females) at a 5600 ft site. The habitat at the lower site is dry Transition zone, with sagebrush, pine grass, and occasional PINUS PONDEROSA. The upper site is Engelmann spruce, subalpine fir, and abundant ground cover including VALERIANA SITCHENSIS, VERATRUM VIRIDE, ANEMONE OCCIDENTALIS, VACCINIUM, LUPINUS, and waist-high dense SALIX. Compares external and skull measurements of subspecies ARTEMISIAE (6Male, 3Female), CHAPMANI (10M, 3F), WRANGELI (2M, 2F), BOREALIS (2M), and DALLI (3?).

Anderson, R. M. 1947. Catalogue of Canadian Recent mammals. Natl. Mus. Can. Bull. 102. 238 pp.

For SYNAPTOMYS BOREALIS: Taxonomic review of specimens by location. Gives 9 subspecies all in single species.

Anderson, R. M., and A. L. Rand. 1943. A new lemming mouse (SYNAPTOMYS) from Manitoba with notes on some other forms. Can. Field-Nat. 57:101-103.

Distribution, measurements, descriptions, and taxonomy.

Anderson, S. 1962. A new northern record of SYNAPTOMYS BOREALIS in Ungava. J. Mammal. 43:421-422.

Record of SYNAPTOMYS for the Ungava peninsula is a new northern record for the species. Bones of 2 lemmings were found in an owl pellet.

Baker, R. H. 1951. Mammals taken along the Alaska Highway. Univ. Kansas Publ ., Mus. Nat. Hist. 5(9):87-117.

Gives lists of all locations trapped and species at each (arranged in species accounts). SYNAPTOMYS BOREALIS taken at 2 of 43 locations trapped. At one 30X60 ft grassy area near McIntyre Creek, Yukon, 2250 ft elevation 5 were taken in 66 trap-nights. In thick sedge bordering a small pond at Deadman Lake , Alaska, 1800 ft., one was taken.

Banfield, A. W. F. 1974. The mammals of Canada. University of Toronto Press, Toronto. Reprinted, 1981.

Detailed accounts of 196 species. Includes information on description, habits, habitat, reproduction, ecological status, and distribution. 46 color plates , 100 black and white drawings. SYNAPTOMYS BOREALIS: distribution; description ; short underground burrows and runways through vegetation; constructs globular nests of grass above ground in winter and below ground in summer; active all winter and throughout 24 hr day; food includes grasses and sedges which are cut into short sections and piled in runways; habitat primarily sphagnum-labrador tea-black spruce bogs but also found in deep mossy spruce woods, wet subalpine meadows, alpine, and sagebrush (one subspp) habitat; breeding season from May-Aug; litters average 4, range 2-8; uncommon in NW Can and rare in E Canada; nine poorly differentiated subspp.

Banfield, F. A. 1941. Notes on Saskatchewan mammals. Can. Field-Nat. 55:117- 123?.

Short accounts of new records. SYNAPTOMYS BOREALIS was collected (adult male) from the edge of a grassy flat bordering a small marshy bay of Emma Lake.

Bangs, O. 1897. On a small collection of mammals from Hamilton Inlet, Labrador. Proc. Biol. Soc. Wash. 11:235-240.

SYNAPTOMYS BOREALIS collected at Fort Chimo, Labrador; description of one male collected.

Bangs, O. 1898. A list of the mammals of Labrador. Amer. Nat. 32:489-507.

An early list of Labrador mammals. Lists Type specimen of SYNAPTOMYS INNUITUS (=BOREALIS) from Fort Chimo, Labrador.

Bangs, O. 1900. Three new rodents from southern Labrador. Proc. New England Zool. Club 2:35-41.

Describes Type specimen of SYNAPTOMYS INNUITUS MEDIOXIMUS (=BOREALIS) from Lance au Loup, Labrador. Adult male with description and measurements.

Beasley, L. E. and L. L. Getz. 1986. Comparison of demography of sympatric populations of MICROTUS OCHROGASTER and SYNAPTOMYS COOPERI. Acta Theriologica 31:385-400.

Both species followed multi-year cycles. Population changes and survival were similar, with lemmings showing less dramatic changes during the cycle.

Beckstrom, S. G. 1993. Food habits of boreal owl during brood-rearing in southwest Montana. Unpubl. ms. 15 pp.

Pellets from 10 nest boxes found CLETHRIONOMYS GAPPERI the most important food item (53.6%). PHENACOMYS INTERMEDIUS was next most important with 20.7% biomass. Small mammals in general were 99% of prey biomass. 8 SYNAPTOMYS BOREALIS were found in 4 nests, comprising 0.7% of the diet.

Booth, E. S. 1947. Systematic review of the land mammals of Washington. Ph.D. Thesis, Wash. State Univ., Pullman.

Good review of knowledge up to that time; has some locations missed by Dalquest (1947). Has information (by subspecies) for all Washington land mammals and includes: dot maps, systematics, taxonomy, descriptions, and habitat. For SYNAPTOMYS BOREALIS: shows 2 locations in the North Cascade Mountains. Only subspecies then known was WRANGELLI but Booth speculated others would be found farther east (he was right). Description and measurements. Habitat is described as wet, boggy places in the mountains.

Clark, B. K. and D. W. Kaufman. 1990. Short-term responses of small mammals to experimental fire in tallgrass prairie. Can. J. Zool. 68:2450-2454.

Short-term response to burning was moving off area by most harvest mice, southern bog lemmings, and prairie voles; deer mice moved onto burned area.

Clough, G. C., and J. J. Albright. 1987. Occurrence of the northern bog lemming, SYNAPTOMYS BOREALIS, in the northeastern United States. Can. Field- Naturalist 101:611-613.

Three specimens of SYNAPTOMYS BOREALIS for Maine and one for New Hampshire are reported. On 18-20 July 1 immature female and 1 adult female (4 embryos) were captured in pitfalls (117 sherman live trap-nights, 108 pitfall trap- nights). Both were captured at 1375 m in a wet sedge meadow dominated by CAREX , sphagnum moss, lichen (CETRARIA NIVALIS), SALIX UVA-URSI, and BETULA GLANDULOSA. Associated species at the site were MICROTUS PENNSYLVANICUS, CLETHRIONOMYS GAPPERI, PEROMYSCUS MANICULATUS, BLARINA BREVICAUDA, and SOREX CINEREUS. A single immature male SYNAPTOMYS BOREALIS was captured on 11 Aug in a stand of dead fir and spruce at

400 m elevation. Understory was dominated by fir, spruce, mountain ash, and paper birch; shrub and ground layer was dense raspberry, ferns, some grass and sedge, and sphagnum in scattered damp areas. The area was trapped in 1982 (360 trap-nights), July 1985 (135 Longworth live trap-nights) and Aug 1985 (300 snap trap-nights). Other mammals at this site included MICROTUS CHROTORRHINUS, M. PENNSYLVANICUS , CLETHRIONOMYS GAPPERI, PEROMYSCUS MANICULATUS, and SOREX CINEREUS. There are now a total of 7 specimens from 4 locations in Maine and New Hampshire.

Coffin, B. and L. Pfannmuller (eds). 1988. Minnesota's endangered flora and fauna. U. Minn. Press, Minneapolis.

Good reference for Minnesota sensitive species with state maps with county of occurrence, status and basis for status, habitat, identification, recommendations, and selected references. SYNAPTOMYS BOREALIS summarizes the 5 locations in N MN where lemmings are known. Suggests the species may be difficult to trap. Habitat given as dominated by sphagnum and graminoids; may include forested bogs or open ericaceous shrublands over total range. Recommend additional sampling by qualified professionals and preservation of large tracts of peatlands.

Cowan, I. M., and C. J. Guiguet. 1965. The mammals of British Columbia. Brit. Columbia Prov. Mus. Handbook 11. 414 pp.

For SYNAPTOMYS BOREALIS: description and measurements; Habitat: usually wet alpine and subalpine meadows; runways and burrows well defined; moves to higher ground in winter; eats sedges, grasses, saxifrages, and other plants; makes small piles of cuttings in runways; deposits droppings in special places where 2 cupfuls may accumulate; 2-8 young per litter, usually 4-5; young born May-Aug; winter nest of dry grass 8" diameter; no citations for any of this information.

Cowan, I. McT. 1939. The vertebrate fauna of the Peace River. District of British Columbia. Occ. Papers B.C. Prov. Mus. 1.

For SYNAPTOMYS BOREALIS: On 28 June found a colony in muskeg and 4 were taken. Habitat was 50 feet square and the "mossy carpet was honeycombed with tunnels." Fecal pellets were strewn about the tunnels, concentrated where feeding was occurring. 1-1.5 inch cuttings of grass were piled throughout the colony. Also caught here were MICROTUS PENNSYLVANICUS. Measurements.

Cross, E. C. 1938. SYNAPTOMYS BOREALIS from Godbout, Quebec. J. Mammal. 19:378.

Single immature taken, with description and measurements.

Dalquest, W. W. 1948. Mammals of Washington. University of Kansas Mus. Nat. Hist. Publ. 2:1-444.

Distributional accounts which include brief descriptions and accounts of habits; dot and associated shading on maps; key to spp. SYNAPTOMYS BOREALIS shows known 2 locations and a possible location (later verified by Wilson, Johnson and Reichel 1980).

Dearden, L. C. 1958. The baculum in LAGURUS and related Microtines. J. Mammal . 39:541-553.

Describes variation in the baculi of LAGURUS. Compares baculi across Microtine genera including LEMMUS, SYNAPTOMYS, DICROSTONYX, CLETHRIONOMYS, PHENACOMYS, and MICROTUS (drawings). SYNAPTOMYS is shown to be most closely related to DICROSTONYX.

Dice, L. R. 1921. Notes on the mammals of interior Alaska. J. Mammal. 2:20-28.

Records of unusual specimens taken in Alaska. Two SYNAPTOMYS BOREALIS taken, one in scrub willows and one in horsetails.

Downing, S. C. 1940. First Ontario record of the subgenus MICTOMYS. Can. Field -Nat. 54:109-110.

One immature male 25 July 1939 at Moosonee, Ontario. Taken on an open bank of a small creek draining a bog. Surrounding area had spruce trees and deep mossy ground cover. Measurements and description.

Dutcher, B. H. 1903. Mammals of Mt. Katahdin, Maine. Proc. Biol. Soc. Wash. 16 :63-72.

Describes 36 mammals known from Mt. Katahdin. For SYNAPTOMYS BOREALIS, 2 were trapped in balsam scrub by a spring at 4500 ft. during >270 trap-nights.

Edwards, R. L. 1963. Observations on the small mammals of the southeastern shore of Hudson Bay. Can. Field-Nat. 77:1-12.

Caught 25 individuals at 5 sites (185 trap-nights); most were caught in open, very wet places. No scat piles or cuttings were associated with this species. Only 2 showed breeding activity, a male with scrotal testes on 23 Aug and a female with 3 embryos on 10 Sept. Most mice appeared to be yearlings. There appeared to be two litters per year, with some young breeding the same summer they were born. Description & measurements.

Foresman, K. R. and D. E. Pearson. 1990. Ecology of the northern bog lemming [abstract]. Sci. Glacier Natl. Park 1990, Ann. Rep. Coop. Park Studies. p. 41.

Relocated Shoofly Meadows site and found lemmings in Numa Ridge Bog in 1990.

Gaines, M. S., C. L. Baker and A. M. Vivas. 1979. Demographic attributes of dispersing southern bog lemmings (SYNAPTOMYS COOPERI) in eastern Kansas. Oecologica (Berlin) 40:91-101.

There was a positive correlation between lemming colonizing removal grids and density of control grids. 41% of losses of control grids were accounted for by dispersal. Residents differed from dispersers by: 1) higher % males; 2) lower % of adult females colonizing grids were in breeding condition; reversed for subadult females; and 3) higher % subadults.

Gaines, M. S., R. K. Rose and L. R. McClenaghan, Jr. 1977. The demography of SYNAPTOMYS COOPERI populations in eastern Kansas. Can. J. Zool. 55:1584-1594.

Annual and multi-year population cycles were found. Adult and juvenile survival was higher in winter than summer. Breeding was higher in summer than winter, but occurred during both periods.

Garton, E. R. 1977. Late Pleistocene and Recent mammals remains from two caves at Bowden, West Virginia [abstract]. Proc. W. Virginia Academy Sci. 49: 41.

Found SYNAPTOMYS BOREALIS in a limestone cave; no time correlation could be done since they were in a cave-stream deposit.

Godin, A. J. 1977. Wild mammals of New England. Johns Hopkins University Press , Baltimore. 304 pp.

Popular account of the mammals of New England. Covers description, distribution, ecology, behavior, age and sex determination, list of specimens examined, records and reports for each species. Literature references and museum sources cited. SYNAPTOMYS BOREALIS "occurs in cold sphagnum bogs, in bluebunch fields matted with weeds, and in dense hemlock and beech woods". Lemmings may build runways above ground or burrow in leaf litter. Nest is lined with leaves, grasses, and sometimes fur, and located either above or below ground. May be in small colonies or burrows of other small mammals. Known to eat raspberry seeds and the fungus ENDOGONE.

Green, M. M. 1930. Notes on some small Canadian mammals. Can. Field-Nat. 44:69.

Two SYNAPTOMYS BOREALIS were taken near Pine Falls in Apr 1929. They were in an open tamarack bog with SOREX HOYI and SOREX CINEREUS. In May 1929 a male was taken 50 miles north of Pas and had side glands 11X7 mm. A female taken 8 May had 3 embryos 30 mm long.

Groves, C. and E. Yensen. 1989. Rediscovery of the northern bog lemming (SYNAPTOMYS BOREALIS) in Idaho. Northw. Nat. 70:14-15.

A single adult male was captured on 14 July 1988 at Cow Creek, Boundary Co., Idaho at 1304 m elevation. The site was at the edge of a sphagnum bog next to an Englemann spruce tree. Dominant vegetation in the bog included: DESCHAMPSIA CAESPITOSA, CAREX ROSTRATA, ERIOPHORUM CHAMISSONIS, BETULA GLANDULOSA, KALMIA MICROPHYLLA, and SPHAGNUM spp. Other small mammals captured at the site included: ZAPUS PRINCEPS, CLETHRIONOMYS GAPPERI, SOREX spp, TAMIAS RUFICAUDUS, and MICROTUS PENNSYLVANICUS. The lemming was taken during 2 nights of trapping with 32 museum special snap traps and 16 pitfalls . The other Idaho SYNAPTOMYS site on Gold Peak Road (Johnson and Cheney 1953) was re-sampled in 1987 but no SYNAPTOMYS taken; it was logged sometime between the original capture and the re-trapping attempt in 1987. States that records of SYNAPTOMYS BOREALIS captured by Larrison (Larrison 1967; Larrison and Johnson 1981) were actually misidentified PHENACOMYS INTERMEDIUS.

Guthrie, R. D. 1968. Paleoecology of a Late Pleistocene small mammal community from interior Alaska. Arctic 21:223-244.

SYNAPTOMYS BOREALIS is currently present at the site but was not found in Late Pleistocene deposits. Guthrie is unsure if it is a post-glacial immigrant or was present but not found.

Hall, E. R. 1981. Mammals of North America. 2nd edition. 2 vol. John Wiley and Sons.

Identification and distribution information for mammals of North America. SYNAPTOMYS BOREALIS: description and measurements; distribution; 9 subspp.

Hall, E. R. and E. L. Cockrum. 1953. A synopsis of the North American Microtine rodents. Univ. Kansas Publ., Mus. Nat. Hist. 5:373-498.

Good for synonymies, distribution, subspecies, key, and citations of original descriptions. For SYNAPTOMYS BOREALIS: places in subgenus MICTOMYS and lists 9 subspecies and their distributions. Gives external measurements as total:118 -135; tail:19-27; hind foot:16-22; ear:12-13; weight 32-34 g (n=2). Pelage description.

Hall, F. S. 1932. A historical resume of exploration and survey - mammal types and their collectors in the state of Washington. Murrelet 13:63-91.

Gives original citation and information from it on the description of SYNAPTOMYS TRUEI (=S. BOREALIS) from the Skagit Valley of Washington in 1859.

Hamilton, W. J., Jr. and J. O. Whitaker, Jr. 1979. Mammals of the eastern United States. Cornell University Press. Ithaca, NY. 346 pp.

Listed by order. Useful information concerning distribution, habits. Provides range maps and illustrations. For SYNAPTOMYS BOREALIS: distribution and description only.

Harper, F. 1961. Land and fresh-water mammals of the Ungava Peninsula. Univ. Kansas Publ., Mus. Nat. Hist. 27: includes pp. 55-62.

For SYNAPTOMYS BOREALIS: measurements and description. On 16 June an adult female was trapped on a mossy log in swamp among tall and low willows, dwarf birch, CAREX?, sphagnum, and liverwort. She had 7 embryos (13mm), enlarged mammary glands (2 pair pectoral, 2 pair inguinal, with drawing), and lateral glands slightly developed (10x4.5mm). On 17 July a male was trapped on a rock in a brook flowing through mossy woods. Surrounding vegetation included white spruce, tamarack, alder, willow (tall and low), Labrador tea, VIBURNUM EDULE, CORNUS CANADENSIS, RUBUS, COPTIS GROENLANDICA, VIOLA, TRIENTALIS BOREALIS, USNEA, and SPHAGNUM. He had moss (HYLOCOMIUM PYRENACIACUM) in his mouth. Testes were 8X5mm; lateral glands greatly developed 14X8 and 2mm thick; a less developed glandular area was located between

each ear and foreleg. Another male found dead on 13 June had testes 7.5X6mm and lateral glands greatly developed 15X7mm. On the lemmings were found a flea (MEGABOTHRIS ASIO ASIO) and 3 species of mites (HEMOGAMASUS ALASKENSIS, LAELAPS ALASKENSIS, HAEMOLAELAPS GLASGOWI).

Heaney, L. R. and E. C. Birney. 1975. Comments on the distribution and natural history of some mammals in Minnesota. Can. Field-Nat. 89:29-34.

Observations on the distribution and natural history of 18 species. SYNAPTOMYS BOREALIS found 10 mi S of Big Falls, an extension of the range in the central U.S. approximately 50 miles to the south of previous records (Wetzel and Gunderson 1949).

Heller, E. 1910. Mammals of the 1908 Alexander Alaska expedition. Univ. Calif . Publ. Zool. 5:321-360.

For SYNAPTOMYS BOREALIS: collected 8 specimens. 3 are from Cordova in “a tangle of rye-grass, stumps, and salmonberry bushes.” Five are from Port Nell Juan in open tundra in very swampy situations near the beach.

Hinton, M. A. C. 1926. Monograph of the voles & lemmings (Microtinae). Vol. 1 . British Mus. Nat. Hist., London.

Taxonomic discussion of the subfamily. Places SYNAPTOMYS in the group Lemmi and says it is the most primitive of the true lemmings (SYNAPTOMYS, LEMMUS, MYOPUS). Divides the genus in two subgenera (SYNAPTOMYS, MICTOMYS) of which MICTOMYS is the most primitive. Long descriptions of skeletal and dental (rootless cheek teeth) differences with excellent drawings of cheek teeth. Says S. BOREALIS has 8 mammae and S. COOPERI 6. Gives 8 species and 9 forms but says many of doubtful validity.

Hoffmann, R. S., P. L. Wright and F. E. Newby. 1969. Distribution of some mammals in Montana. I. Mammals other than bats. J. Mammal. 50(3): 579-604.

Distribution and specimen records listed for select mammals in Montana. SOREX PREBLEI, SCIURUS NIGER, PEROGNATHUS PARVUS, and PROCYON LOTOR are reported for the first time in Montana. Not extensive data. Two SYNAPTOMYS BOREALIS taken at same site in Glacier NP as Wright (1950) on 20-21 July 1953 but not taken in other of 17 years trapped since 1949. Gives dates, 15 Sep 1953 and 12 Sept 1956 for 2 additional specimens taken at Anaconda Creek, Glacier N.P. (see Weckwerth and Hawley 1962).

Hooper, E. T. and B. S. Hart. 1962. A synopsis of Recent North American Microtine rodents. Misc. Publ. Mus. Zool., Univ. Michigan 120. 68 pp.

Systematic study primarily using glans characteristic and comparing cranial and external characteristics. Includes measurements and description of glans for a wide range of rodents including SYNAPTOMYS BOREALIS. The 2 SYNAPTOMYS species are shown to be closely related and the most closely related to them may be PHENACOMYS INTERMEDIUS.

Howell, A. B. 1927. Revision of the American lemming mice (genus SYNAPTOMYS). N. Amer. Fauna 50. 37 pp.

Taxonomic revision of the genus SYNAPTOMYS. Gives distribution maps, drawings of dental and cranial characteristics, descriptions of the different subspecies (7), Type localities and citations, and lists of specimens. Ecological information is primarily based on SYNAPTOMYS COOPERI.

Ingles, L. G. 1965. Mammals of the Pacific States. Stanford University Press, Stanford, California. 506 pp.

Very brief description, habitat, shaded map, and key to mammals in WA, OR, and CA.

Johnson, M. L. and P. W. Cheney. 1953. SYNAPTOMYS in Idaho and northeastern Washington. Murrelet 34:10.

SYNAPTOMYS BOREALIS was collected at one site each in WA and ID. Two immature specimens (1 male, 1 female) were collected at Sema Meadows, Washington, 3000 ft, “at the edge of open beaver meadows” on 4-5 Aug 1952. Two adults (1 male, 1 female) were collected on Gold Peak Road, Idaho, 4200 ft, in a small bog along a stream on 8 Aug 1952.

Jones, J.K., Jr. and E.C. Birney. 1988. Handbook of mammals of the north- central states. U. Minn. Press, Minneapolis. 346 pp.

Semi-popular account of mammals of the North-Central U.S. with general distribution maps (shading only), description with measurements, some natural history, and selected references. SYNAPTOMYS BOREALIS habitat is primarily bogs and marshy areas, but occasionally occurs in more xeric areas including dry woods or sagebrush. It digs short burrows and uses conspicuous runways. Globular nests of dry vegetation are built above ground in winter and below in summer. They do not hibernate. Food is grasses and sedges. Fecal pellets are bright green. The middle claws are enlarged during winter, presumably an adaptation to living in snow. Breeding season form May-Aug. Females produce several litters per year. Number of young range from 2-8, averaging 4. Females have 4 pair mammae (2 pectoral, 2 inguinal). Presumably northern bog lemmings have 3 maturational pelages and 2 seasonal molts in adults as do other microtines.

Jonkel, C. J. 1959. An ecological and physiological study of pine marten. M.S . Thesis, Montana State Univ., Bozeman. 81 pp.

Concluding phase of a long-term (1952-1958) study in Glacier NP. Investigated minimum breeding age, time of implantation, and ensuing time to parturition and continued studies on the relationship between small mammals and marten population densities. 2 individual SYNAPTOMYS BOREALIS trapped at two grids during 2 years.

Koenigswald, W. V., and L. D. Martin. 1984. Revision of the fossil Lemminae (Rodentia, Mammalia). Spec. Publ. Carnegie Mus. Nat. Hist. 9:122-137.

Fossil history of the Lemminae is revised and three genera recognized: LEMMUS, SYNAPTOMYS, and MICTOMYS. DICROSTONYX and LAGURUS are excluded. Speculates Lemminae originated in Eurasia and SYNAPTOMYS immigrated to North America in the late Pliocene. Uses enamel patterns for comparison. Places SYNAPTOMYS BOREALIS in the genus MICTOMYS.

Krebs, C. J. and I. Wingate. 1985. Population fluctuations in the small mammals of the Kluane Region, Yukon Territory. Can. Field-Nat. 99:51-61.

Looks at population changes in small mammals in the Yukon. Caught 7 SYNAPTOMYS BOREALIS in 110,628 snap-trap nights.

Larrison, E. J. 1970. Washington mammals, their habits, identification, and distribution. Seattle Audubon Soc., Seattle, Wash.

Gives brief and anecdotal information about life history, identification, and distribution of Washington mammals. Lists locations for SYNAPTOMYS BOREALIS in Washington including E. Fork Gold Creek [specimens from that site have been re-identified as PHENACOMYS. Use of life history information for bog lemmings from this book is problematical since Larrison had misidentified material from both WA and ID (J.D. Reichel, pers. comm.).

Larrison, E. J. and D. R. Johnson. 1981. Mammals of Idaho. Univ. Press of Idaho, Moscow. 166 pp.

Gives brief and anecdotal information about life history, identification, and distribution of Idaho mammals. Lists locations for SYNAPTOMYS BOREALIS in Idaho; Larrison states that some specimens lack grooves in the upper incisors [these and perhaps others have been re-identified as PHENACOMYS. Use of life history information for bog lemmings from this book is problematical since Larrison had misidentified material from both WA and ID (J.D. Reichel, pers. comm.).

Layser, E. F. and T. E. Burke. 1973. The northern bog lemming and its unique habitat in northeastern Washington. Murrelet 54:7-8.

SYNAPTOMYS BOREALIS is described from Bunchgrass Meadows in NE Washington at 5000 ft. Area is a true bog/fen of over a square mile with a few small spruce and fir islands. Plants present included: BETULA GLANDULOSA, CAREX LIMOSA, C. SCOPULORUM, DROSERA ANGLICA, LYCOPIUM SITCHENSE, KALMIA POLIFOLIA, SCHEUCHZERLA PALUSTRIS, SIBBALDIA PROCUMBENS, and SPHAGNUM. Authors list bird and herp spp also present. Present on the site were piles of grass and sedge cuttings at the base of small shrubs and along runways; most common cuttings were CAREX SCOPULORUM. A single bog lemming was captured during 140 snaptrap nights on 10-11 July 1972. Suggest threats to population may include: overgrazing, compaction of snow (destroying runways and nests) by snowmobiles , and impoundments which could flood the area.

Linzey, A. V. 1983. SYNAPTOMYS COOPERI. Mammalian Species 210:1-5.

Good summary of available information.

Linzey, A. V. 1984. Patterns of coexistence in SYNAPTOMYS COOPERI and MICROTUS PENNSYLVANICUS. Ecol. 65:382-393.

SYNAPTOMYS are excluded from preferred habitats by MICROTUS. The following patterns were observed: 1) In undisturbed sympatric populations, microhabitat partitioning was observed

when habitat was marginal for voles. 2) Lemming microhabitat had more trees and shrubs when voles were present. 3) If vole populations declined, lemmings shifted into habitat previously occupied by voles. 4) Removal of voles from a grid resulted in immediate colonization by lemmings. 5) A year following lemming removal, former lemming habitat remained empty despite an increasing vole population. 6) Food of lemmings was less digestible than voles on grids where both occurred. 7) When voles were removed from a grid, lemming diets became more similar to voles (72 vs 37%).

Lyon, M. W., Jr. and W. H. Osgood. 1909. Catalogue of the Type specimens of mammals in the United States National Museum, including the Biological Survey Collection. U. S. Natl. Mus. Bull 62. 325 pp.

Lists the Type specimens with citations of original description, what is present in collection and the state of the material.

Manville, R. H. and S. P. Young. 1965. Distribution of Alaskan mammals. Bur. Sport Fish Wildl. Circular 211. 74 pp.

Provides dot range map for SYNAPTOMYS BOREALIS. Describes habitat as wet tundras and sphagnum bogs, occasionally dry or moist meadows.

Martell, A. M. 1974. A northern range extension for the northern bog lemming, SYNAPTOMYS BOREALIS BOREALIS (Richardson). Can. Field-Nat. 88:348.

Near Inuvik, 4 specimens (3 M, 1 F) captured in 75,000 trap-nights.

Merriam, C. H. 1896. Revision of the lemmings of the genus SYNAPTOMYS, with descriptions of new species. Proc. Biol. Soc. Wash. 10:55-64.

Descriptions and some locations. First to break SYNAPTOMYS into two subgenera.

Miller, G. S., Jr. 1896. Genera and subgenera of voles and lemmings. N. Amer. Fauna 12. 84 pp.

Gives description of both species of SYNAPTOMYS, including pelage, measurements, skull, and teeth.

Morlan, R. E. 1989. Paleoecological implications of Late Pleistocene and Holocene microtine rodents from the Bluefish Caves, northern Yukon Territory. Can. J. Earth Sci. 26:149-156.

A single SYNAPTOMYS BOREALIS found (in Holocene birch phase sediment) among 10s of thousands of small mammal remains. Currently inhabits the area.

Munro, J. A. 1947. Observations of birds and mammals in central British Columbia. Occasional Papers B.C. Prov. Mus. 6.

For SYNAPTOMYS BOREALIS: 2 locations in central BC; female w/ 4 embryos taken 15 May; all trapped in runways through VACCINIUM; associated species included MICROTUS PENNSYLVANICUS and CLETHRIONOMYS GAPPERI.

Osgood, W. H. 1900. A biological reconnaissance of the Yukon River Region: annotated account of mammals. N. Amer. Fauna 19:1-45.

Collected SYNAPTOMYS DALLI (=BOREALIS) at several locations. At one location near Lake Lebarge they were in long grass at the edge of a small pond, while other locations were in cold boggy places near small streams. Gives description and measurements.

Osgood, W. H. 1904. A biological reconnaissance of the base of the Alaska Peninsula. N. Amer. Fauna 24. 86 pp.

Collected 24 SYNAPTOMYS DALLI (=BOREALIS) of all age and sex categories. Found much age variation in skull measurements. Usually found in small colonies “in very wet swampy places, preferably in wet moss.” One area was a small boggy place partially filled with dead logs and branches and overgrown with moss. Says they make runways slightly smaller than MICROTUS and usually in “moss rather than grass and weeds.” Gives description and measurements.

Osgood, W. H. 1904. Natural history of the Cook Inlet region, Alaska. N. Amer . Fauna 21:51-81.

Collected 1 SYNAPTOMYS DALLI (=BOREALIS) a small peat bog near Hope. Gives description and measurements.

Osgood, W. H. 1907. Some unrecognized and misapplied names of American mammals . Proc. Biol. Soc. Wash. 20:43-52.

Redescribes Type specimen and gives some of original description of ARVICOLA (=SYNAPTOMYS) BOREALIS from Richardson (1828).

Osgood, W. H. 1909. Biological investigations in Alaska and Yukon Territory. N . Amer. Fauna 30. 86 pp.

For SYNAPTOMYS BOREALIS: “Rather rare, only 4 specimens taken” in E Central AK. 1 taken in a “grassy swamp” other 3 near timberline at the head of Seward Creek. In the Ogilvie Range 2 were taken in “cold Swamps.” In the MacMillan region 5 were taken in a sphagnum swamp near mouth of Russell Creek.

Peterson, R. L. 1966. The mammals of eastern Canada. Oxford University Press. Toronto, Canada. 465 pp.

Good general reference; body measurements; references. For SYNAPTOMYS BOREALIS: rarest rodent in collections for eastern Canada. Description. Notes that 2 specimens taken in

mid-January and mid-April at Indian House Lake, Quebec, showed extreme enlargement of 2 middle claws on the front feet; it is unknown if this is normal since only 2 specimens have ever been taken during this season. A series of 6 specimens taken in northern Quebec were from a dry, partly wooded habitat. Specimens of three pregnant females in the Royal Ontario Museum taken in June had 4, 4, and 7 embryos.

Preble, E. A. 1899. Description of a new lemming mouse from the White Mountains, New Hampshire. Proc. Biol. Soc. Wash. 13:43-45.

Description of the subspecies SYNAPTOMYS BOREALIS SPHAGNICOLA based on one specimen trapped at Fabyans (1600') near the base of Mt. Washington on 29 June 1898. Habitat "is swampy and quite densely carpeted with moss..." Associated species included MICROTUS, PEROMYSCUS, BLARINA, CLETHRIONOMYS, ZAPUS HUDSONICUS, and NAPOZAPUS INSIGNUS.

Preble, E. A. 1902. A biological investigation of the Hudson Bay Region. N. Amer. Fauna 22. 140 pp.

For SYNAPTOMYS BULLATUS (=BOREALIS): Only trapped 2 specimens, one near Norway House. The other was a female with 6 embryos in a swamp bordering the Echimamish River on June 25.

Preble, E. A. 1902. Descriptions of new species of SYNAPTOMYS and PHENACOMYS from MacKenzie, Canada. Proc. Biol. Soc. Wash. 15:181-182.

Description of new species SYNAPTOMYS BULLATUS (=S. BOREALIS) from Great Slave Lake, Canada from a skin and skull of adult male.

Preble, E. A. 1908. A biological investigation of the Athabaska-Mackenzie Region. N. Amer. Fauna 27. 574 pp.

For SYNAPTOMYS BOREALIS: took 8 near site (Ft. Franklin) of those originally described by Richardson (1829) and quotes extensively from that paper. Caught one female with 4 embryos. Habitat at various sites where lemmings were captured include: 1) border of a small meadow; 2) wet swamp; 3) near small muskeg ponds; and 4) marsh. Says Loring found SYNAPTOMYS rather common in October in a sphagnum swamp and caught about a dozen. Gives measurements and descriptions and merges S. DALLI with S. BOREALIS as S.B. DALLI.

Prince, L. A. 1942. SYNAPTOMYS BOREALIS from Fort Severn, Hudson Bay, Ontario . J. Mammal. 23:216.

An immature male SYNAPTOMYS BOREALIS was trapped at Ft. Severn on 11 July 1940. Was taken in a "water trap" on alder and willow bordered bank of a stream draining a black spruce bog. Gives measurements of the single specimen.

Rand, A. L. 1945. Investigations on the Canal Road, Yukon and Northwest Territories, 1944.. Natl. Mus. Can. Bull. 99.

For SYNAPTOMYS BOREALIS: 7 taken in 400 trap-nights in open, wet moss, sedge, willow

and spruce swamp on Lapie River. Also taken were MICROTUS PENNSYLVANICUS. At Mount Sheldon 12 were taken in marshy sedge fringing ponds in a dwarf birch flat 11-15 Aug. On 22-25 Aug 7 were taken in a wet grassy glade on the Macmillan River. In all cases the species was very local, with none being caught during extensive trapping in the surrounding area.

Rand, A. L. 1945. Mammals of Yukon. Natl. Mus. Can. Bull. 100. 93 pp.

For SYNAPTOMYS BOREALIS: description and measurements. States "...scarce animal, found in grass and sedge areas in bogs and marshes where it makes runways" but no indication this is based on observations or literature or?

Reichel, J. D. 1984. Ecology of Pacific Northwest alpine mammals. Unpubl. Ph.D . Thesis, Wash. State U., Pullman. 91 pp.

Information on distribution, dispersal, population structure and habitat use of alpine areas in WA and OR by small mammals. For SYNAPTOMYS BOREALIS one new site, and additional information on another site (Wilson et al. 1980), is given. At sites where lemmings were trapped, Gypsy Peak (918 snap trap-nights) and Slate Peak (1173 snap trap-nights) each produced a single animal (one male, one female). The Gypsy Peak site was fellfield habitat, while the Slate Peak site was a sedge/graminoid wet meadow. Lemmings were not relocated at the Cascade Creek site of Shaw (1930).

Reichel, J. D. and S. G. Beckstrom. 1993. Northern bog lemming survey: 1992. [Unpublished report] Montana Natural Heritage Program. Helena, MT. 64 pp.

Survey of 21 sites in western Montana for SYNAPTOMYS BOREALIS using primarily snaptraps (some comparisons using live traps and pitfalls). Found 5 new sites including the southern-most sites in western North America (map). Compares baits. Lemmings were captured at elevations from 4760-6520 feet. All sites had thick mats of sphagnum moss present. Bog birch and/or a dwarf willow were present at all sites. At sites where lemmings were found, it took 5-140 trap- nights for the first lemming capture; in contrast, 240-556 trap-nights were tabulated at sites where none were captured. Other species captured at sites with bog lemmings included: MICROTUS PENNSYLVANICUS, CLETHRIONOMYS GAPPERI, SOREX, and PHENACOMYS INTERMEDIUS. Includes research needs and methods, management recommendations, and references.

Rhoads, S. N. 1894. Descriptions of a new subgenus and new species of arvicoline rodents from British Columbia and Washington. Proc. Acad. Nat. Sci . Philadelphia 1894:282-288.

Description of Topotype of ARVICOLA BOREALIS (=SYNAPTOMYS BOREALIS) of an adult female taken near Ft. Anderson, north of Great Bear Lake. [NOTE: drawing of dentition looks like MICROTUS not SYNAPTOMYS BOREALIS].

Rose, R. K. and A. M. Spevak. 1978. Aggressive behavior in two sympatric microtine rodents. J. Mammal. 59:213-216.

SYNAPTOMYS were less aggressive and showed more avoidance than MICROTUS in lab encounter trials.

Saunders, W.E. 1927. PHENACOMYS UNGAVA in Ontario. J. Mam. 8:305-307.

Notes on captures of PHENACOMYS UNGAVA (=INTERMEDIUS) and SYNAPTOMYS. Caught a SYNAPTOMYS almost daily.

Scott, P. A. and R. I. C. Hansell. 1989. The lemming community on the lichen- heath tundra at Churchill, Manitoba. Can. Field-Nat. 103:358-362.

Describes lemming community by species and habitat. For SYNAPTOMYS BOREALIS only 2 were captured (2360 trap-nights), one each in a CAREX-moss-SALIX community and a SALIX community. Other species present on the sites of capture included: DICROSTONYX RICHARDSONI and MICROTUS PENNSYLVANICUS.

Seton, E. T. 1909. Life-histories of northern animals. An account of the mammals of Manitoba. Vol. 1. Charles Scribner's Sons, New York.

Repeats other literature briefly (description, distribution, habitat of cold sphagnum bogs). No original information except "shy, secretive, nocturnal" but no citation or indication of where the information came from.

Severinghaus, W. D. 1981. Methods useful in distinguishing Microtines sympatric with the subgenus PEDOMYS. J. Tenn. Acad. Sci. 56:20-22.

Shaw, W. T. 1930. The lemming mouse in North America and its occurrence in the state of Washington. Murrelet 11:7-10.

SYNAPTOMYS BOREALIS (immature) was first captured in Washington in "the Skagit Valley, Skagit Co. on 6 Aug 1859. At the head of Cascade Creek a single individual was taken on 30 Jul 1923 and 11 more during summer 1926; none were trapped in 1928 and 1929 at the same location. The location was at 5000 ft at the head of the drainage in a bog-like area. The bog had many logs from avalanches, PERNASSIA FIMBRIATA, CAREX SPECTABILIS, HABENARIA SACCATA, TOFIELDIA OCCIDENTALIS, MIMULUS TILINGI, M. LEWISII, and a thick carpet of moss (HYPNUM).

Smith, H. C. 1993. Alberta mammals, an atlas and guide. Prov. Mus. Alberta, Edmonton. 238 pp.

Good general information guide with keys, dot maps, habitat, status in Alberta , and measurements. For SYNAPTOMYS BOREALIS: identifying characteristics and description; mapped locations in N part of Alberta down W side in mountains to within 150 km of US border; status is uncommon though widely distributed; habitat is "moist meadows and bogs;" table with weight and external measurements for male (n=15) and female (n=4) lemmings.

Smith, R. W. 1940. The land mammals of Nova Scotia. Amer. Midl. Nat. 24:213- 241.

Short accounts of new records during 1925-1940. SYNAPTOMYS COOPERI was collected but S. BOREALIS was not.

Smits, C. M. M., B. G. Slough and C. A. Yasui. 1989. Summer food habits of sympatric arctic foxes, ALOPEX LAGOPUS, and red foxes, VULPES VULPES, in the northern Yukon Territory. Can. Field-Nat. 103:363-367.

Diets of both foxes were similar with small mammals predominating. SYNAPTOMYS BOREALIS was up to 3.7% frequency in the diet at some locales for Arctic Fox.

Soper, J. D. 1948. Mammal notes from the Grande Prairie - Peace River region, Alberta. J. Mammal. 29:49-64.

For SYNAPTOMYS BOREALIS: “scarce and local.” One male taken in moist spruce woods near shore of Lake Ray, Alberta on 6 July 1944. Measurements and pelage description.

Soper, J. D. 1973. The mammals of Waterton Lakes National Park Alberta. Can. Wildl. Serv. Rep. Series 23:1-57.

No SYNAPTOMYS BOREALIS have been found in Park. Short summary of nearby locations and general information.

Swath, H. S. 1922. Birds and mammals of the Stikine River region of northern British Columbia and southeastern Alaska. Univ. Calif. Publ. Zool. 24:125-314.

For SYNAPTOMYS BOREALIS: Great Glacier on Stikine River, B.C.; 3 males caught; description; habitat- alder thicket.

True, F. W. 1894. Diagnoses of new North American mammals. Proc. U.S. Natl. Mus. 17:241-243.

Description of Type of MICTOMYS INNUITUS (=SYNAPTOMYS BOREALIS) collected Fort Chimo, Ungava, Labrador by L.M. Turner spring 1884. Nursing female.

Weckwerth, R.P. and V.D. Hawley. 1962. Marten food habits and population fluctuations in Montana. J. Wildl. Manage. 26(1):55-74.

A 5 year investigation of the relationships between marten population fluctuations, food habits, & prey densities in Glacier NP. Foods were mostly mammals—Cricetidae. Varied with season & availability; population trends strongly influenced by prey densities. SYNAPTOMYS BOREALIS was trapped in 2 of 5 years trapping was done. Marten scats contained SYNAPTOMYS BOREALIS at a 1.6% frequency during the study, while lemmings comprised only 2 of 223 small mammals trapped.

Wetzel, R. M. and H. L. Gunderson. 1949. The lemming vole, SYNAPTOMYS BOREALIS , in northern Minnesota. J. Mammal. 30:437.

Gives locations for 1 immature female (5 Aug 1932) and 1 adult male (27 July 1948).

Wilson, C., R. E. Johnson, and J. D. Reichel. 1980. New records for the northern bog lemming in Washington. Murrelet 61:104-106.

Describes 3 new sites for SYNAPTOMYS BOREALIS in Washington. One individual (immature, sex unknown) was collected 22 Jun 1979 in a wet (standing water) hummocky sedge meadow with willow and bog birch at 6100 ft. On 25 June 1980 an adult male was collected at a similar site (less hummocky, no bog birch) at 5400 ft, about 6 mi from the first site. At both these sites MICROTUS PENNSYLVANICUS was also trapped. An immature female was captured at the third site (extreme NE WA) at 7250 ft on 23 Aug 1980. The habitat was a barren alpine ridge (15% vegetative cover) at least 900 vertical ft above the nearest boggy meadow.

Wright, P. L. 1950. SYNAPTOMYS BOREALIS from Glacier National Park, Montana. J . Mammal. 31(4):460.

First record of northern bog lemming in Montana. Adult male caught. HABITAT: a swampy area; plants included Englemann spruce, timothy, false hellebore, alder, nannyberry, cow parsnip, horsemint, yellow monkey flower, and snowberry . ASSOCIATED SPECIES included: MICROTUS PENNSYLVANICUS and SOREX VAGRANS. TRAPPING SUCCESS: 1 lemming in 62 trap-nights; not found at same site during 200 trap-nights 2 months later.

Wrigley, R. E. 1974. Ecological notes of animals of the Churchill region of Hudson Bay. Arctic 27:201-214.

One SYNAPTOMYS BOREALIS collected in sedge-moss tundra 35 mi. NW of Churchill.

Youngman, P. M. 1964. Range extensions of some mammals from northwestern Canada. Natl. Mus. Can., Nat. Hist. Paper 23. 6 pp.

For SYNAPTOMYS BOREALIS: lists far north records including Old Crow and Rampart House, Yukon, the farthest know north records for the species at the time.

Youngman, P. M. 1968. Notes on mammals of southeastern Yukon Territory and adjacent Mackenzie District. Natl. Mus. Can. Bull. 223:70-86.

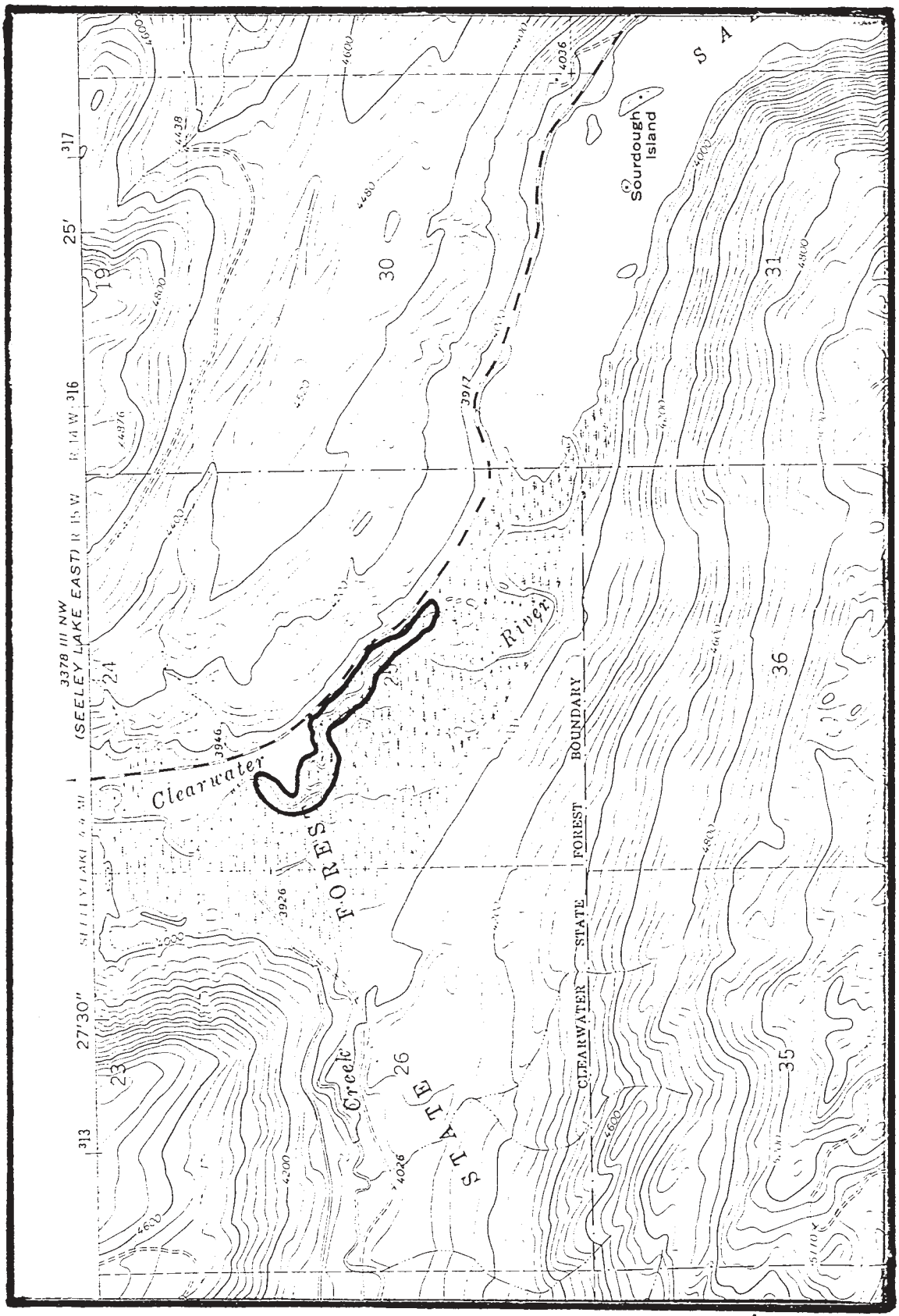
For SYNAPTOMYS BOREALIS: collected in the N. W. T.: 1) a male and nonparous female in a hot spring meadow with MICROTUS PENNSYLVANICUS and M. LONGICAUDUS at 4000 ft, Flat River; 2) one at a marsh at Glacier Lake, 2500 ft; in the Yukon: 3) a male in riparian brushlands 5 mi E of Little Hyland River, 6000 ft and a male at 4000 ft; 4) 11 males and 4 females in white spruce at North Toobally Lake, 2200 ft.

Youngman, P. M. 1975. Mammals of the Yukon Territory. Natl. Mus. Canada, Publ . Zool. 10. 192 pp.

Very good general reference with sections on environmental influences, vegetation and refugium effects on mammal distribution. Species accounts have detailed taxonomic synonymies, dot maps, external and skull measurements, and remarks on fossils, habitat, and ecology. For SYNAPTOMYS BOREALIS: distributed throughout the wooded portion of the Yukon. Has external and skull measurements of males (n=18) and females (n=5-6); pelage description. Suggests that S. BOREALIS speciated in a south-western refugium and is a post- glacial immigrant to the north. Collected in the Yukon “between 800 and 6000 ft mostly in bogs and marshes.” Stated 10 pregnant females averaged 4.4 (3-6) embryos.

APPENDIX 1

Maps of sites surveyed for northern bog lemmings

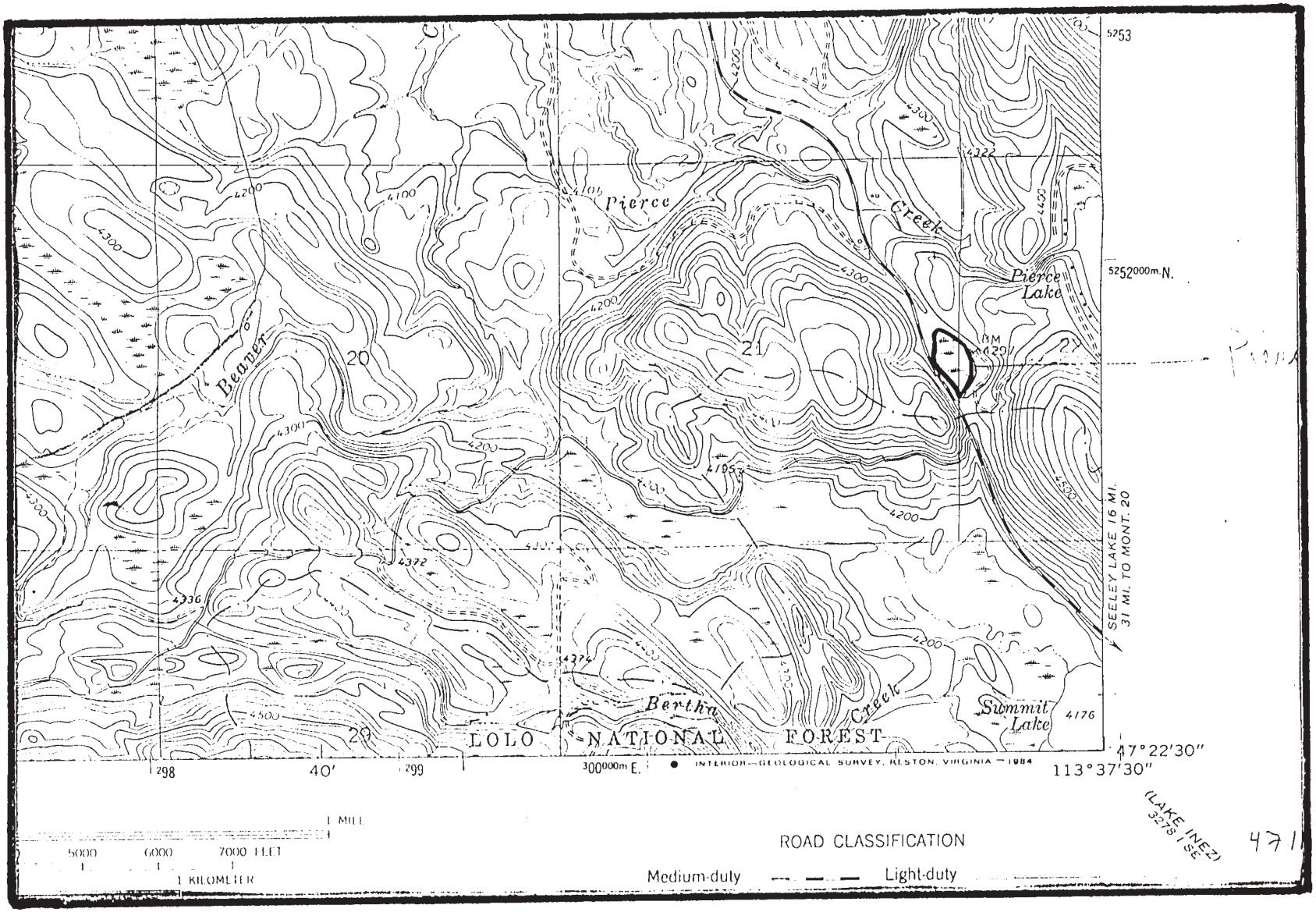


N. of Salmon Lake

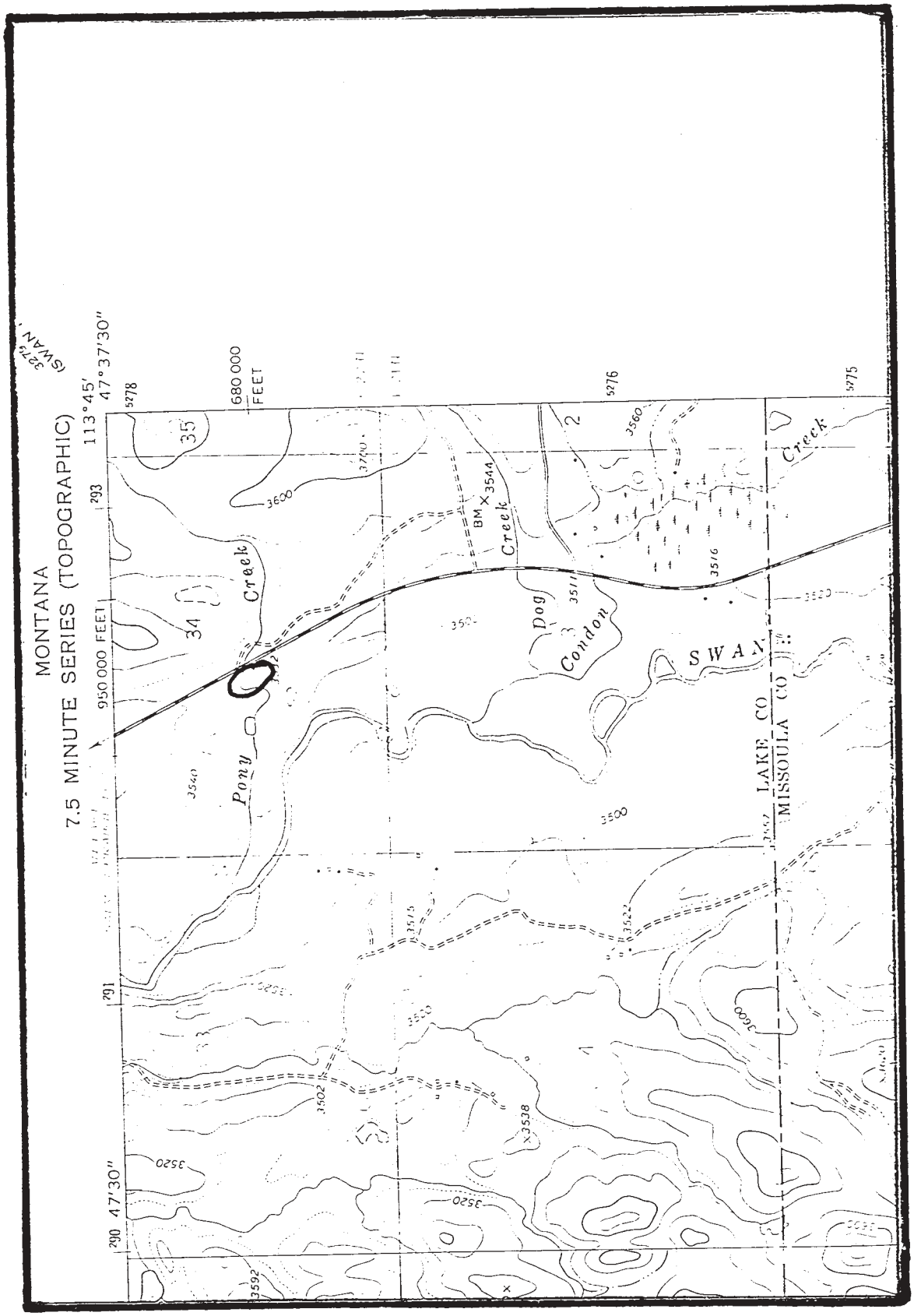
USGS Salmon Lake 7.5'

Pierce Bog

USGS Cygnet Lake 7.5'

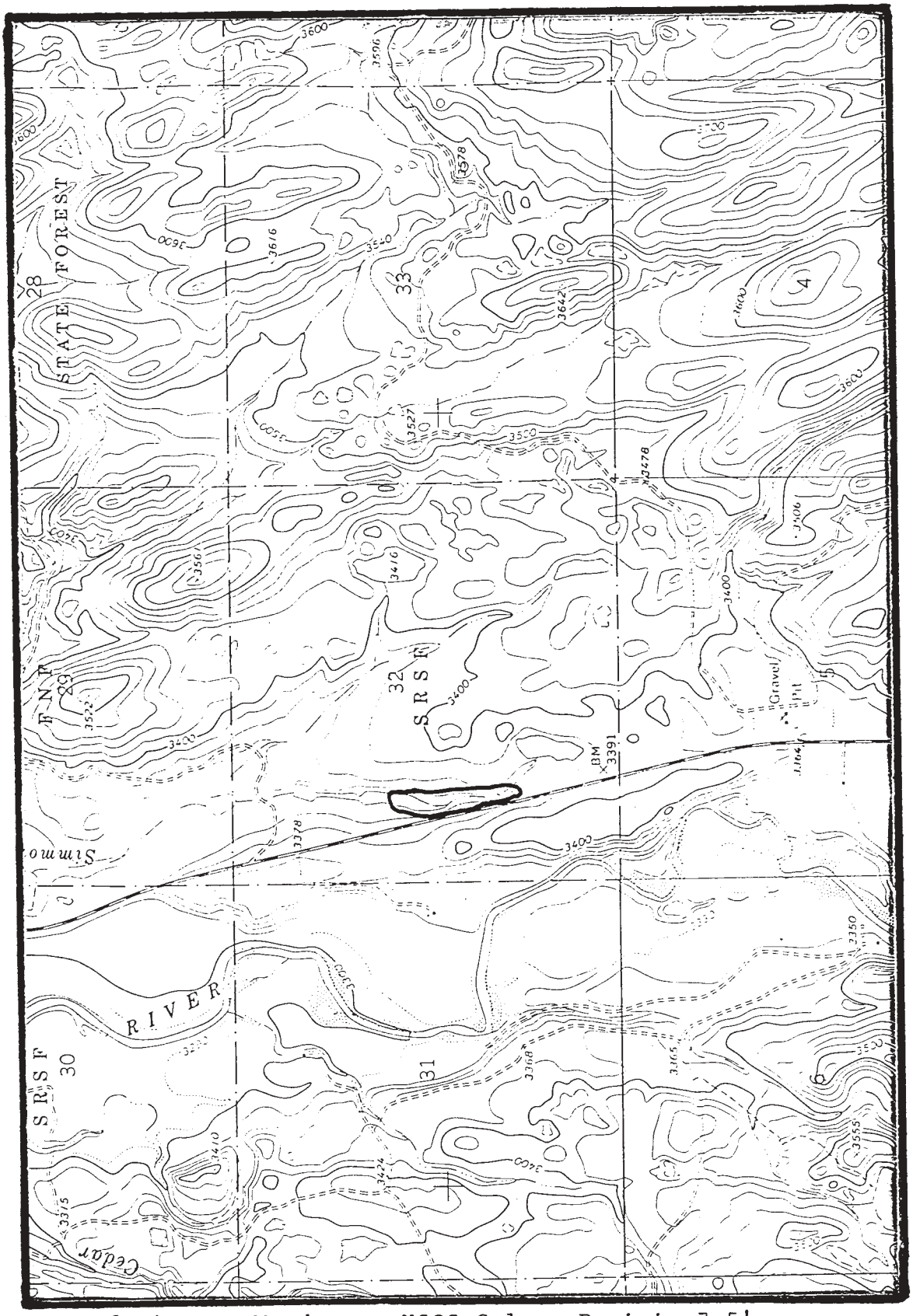


471

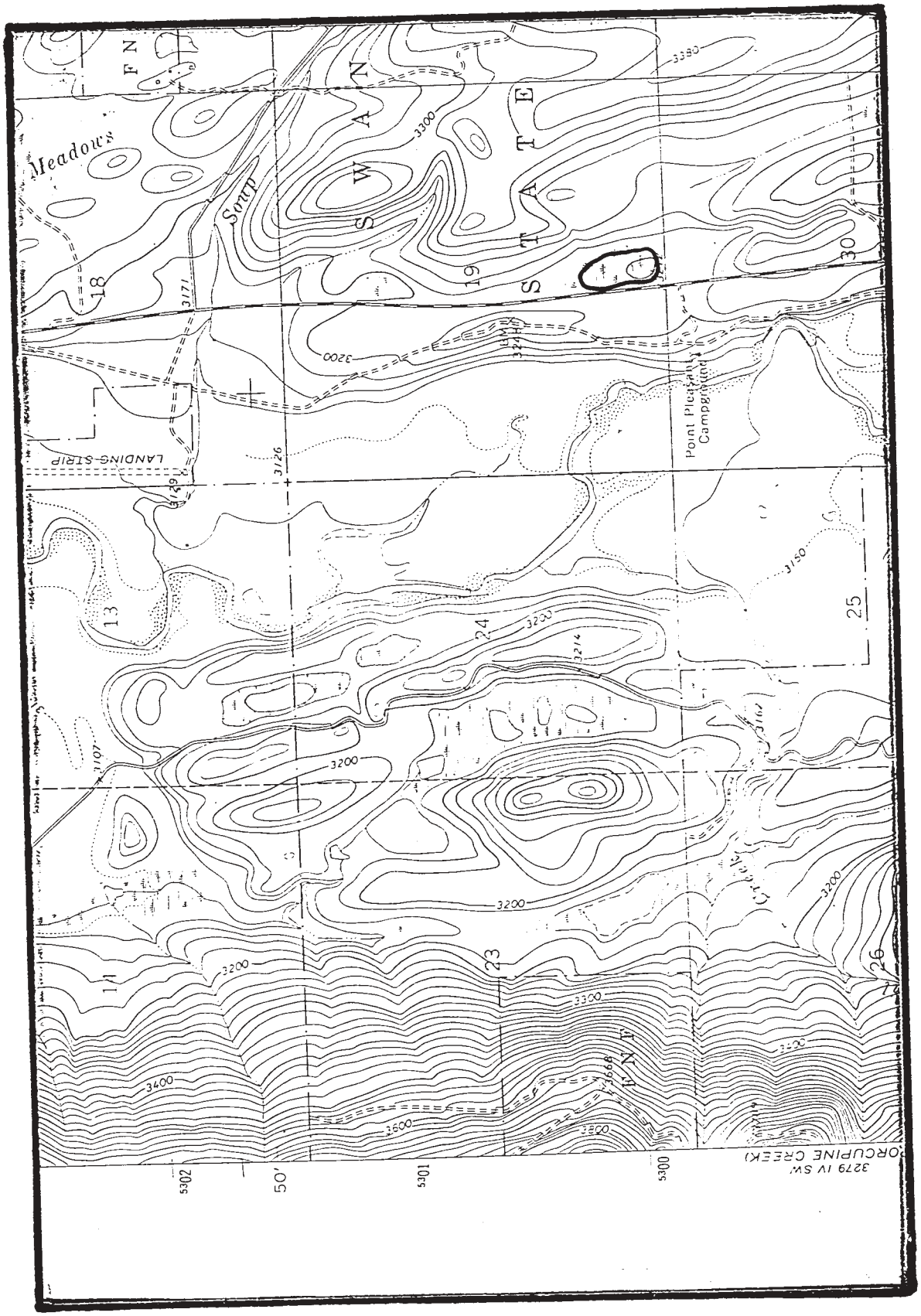


Mile 49 Pond

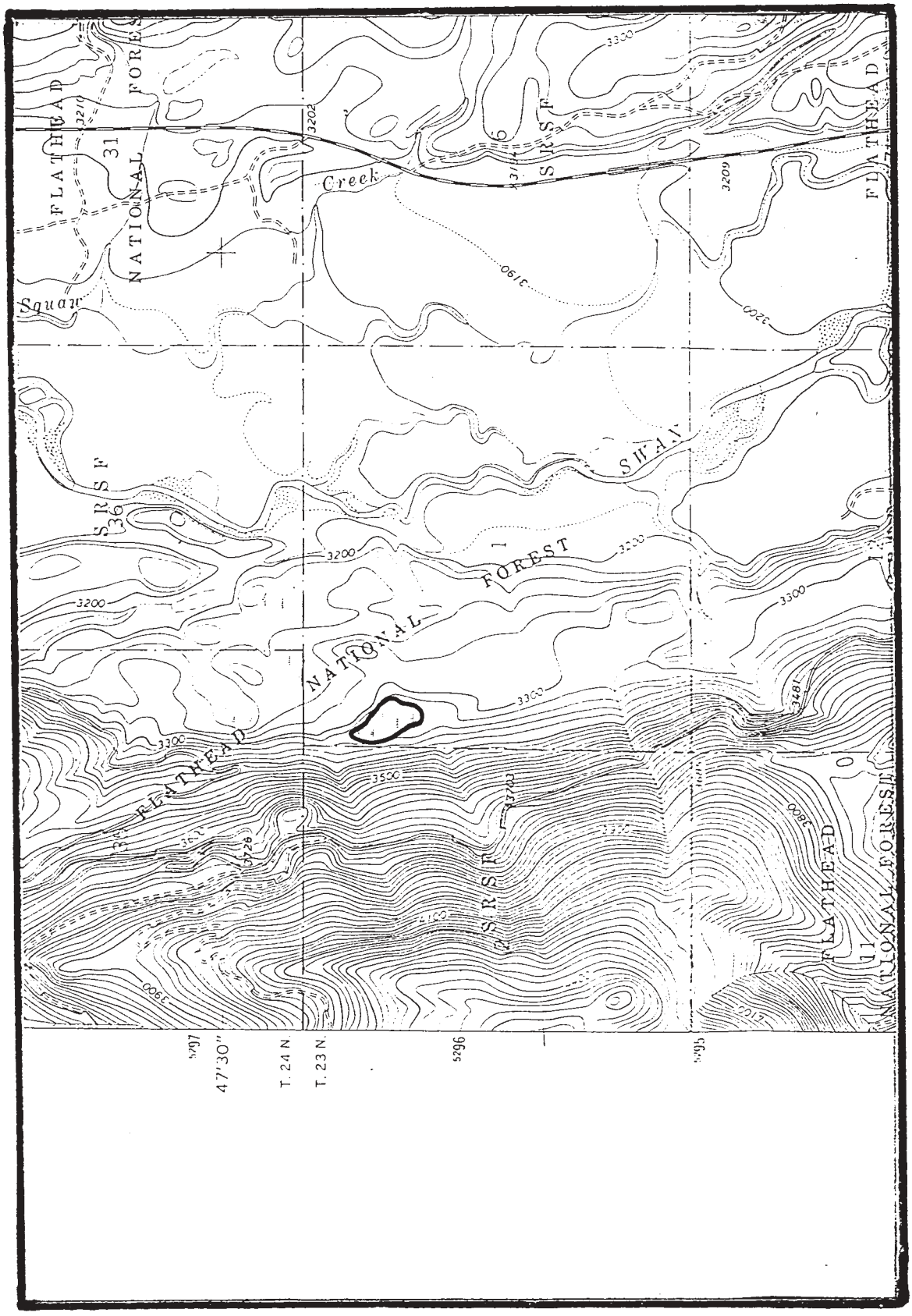
USGS Peck Lake 7.5'



S. of Simmons Meadows USGS Salmon Prairie 7.5'



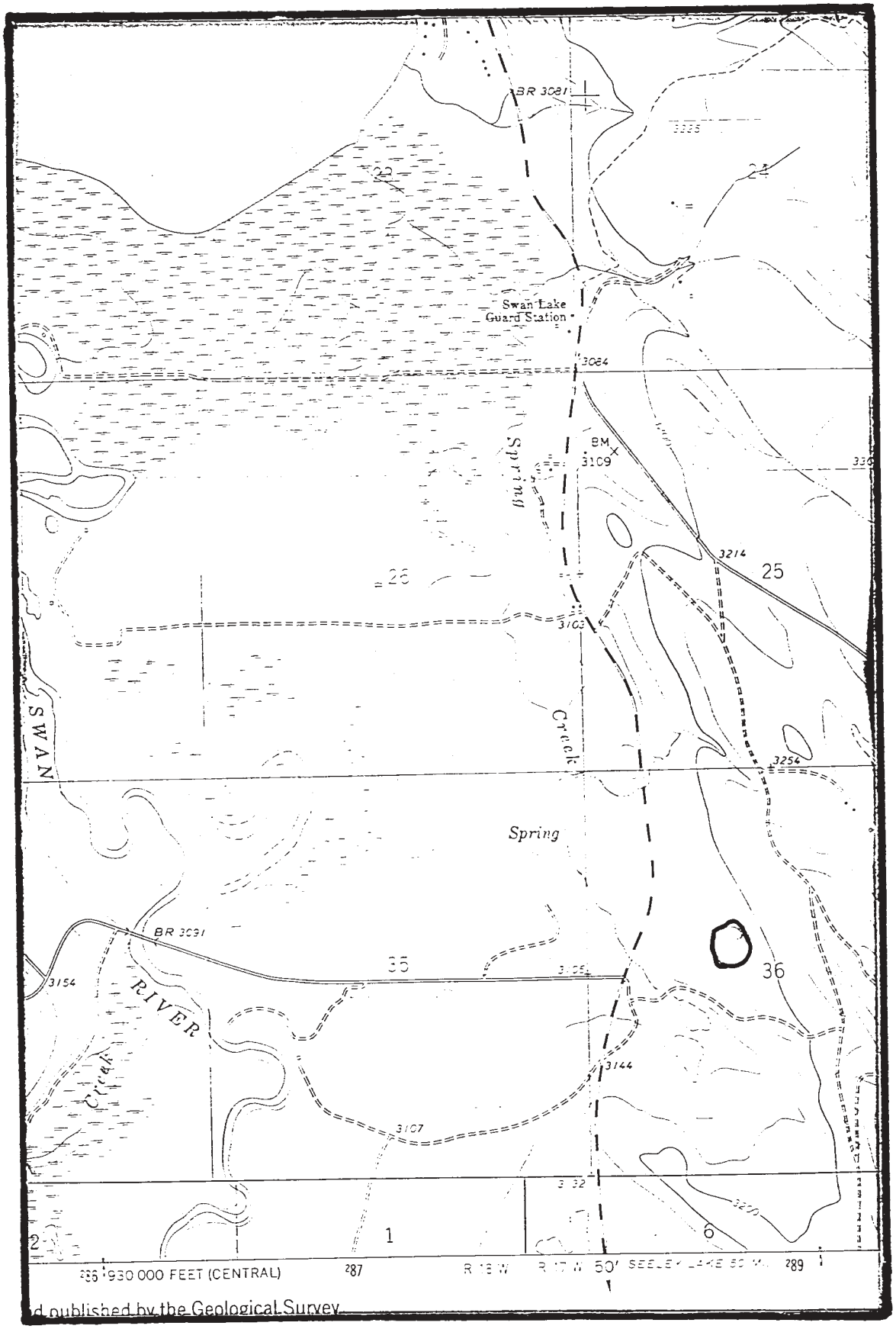
Point Pleasant Fen USGS Cilly Creek 7.5'



Plum Creek Fen

USGS Cilly Creek 7.5'

Swan River Fen PRNA USGS Cilly Creek 7.5'



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Lost Creek Meadows USGS Swan Lake 7.5'